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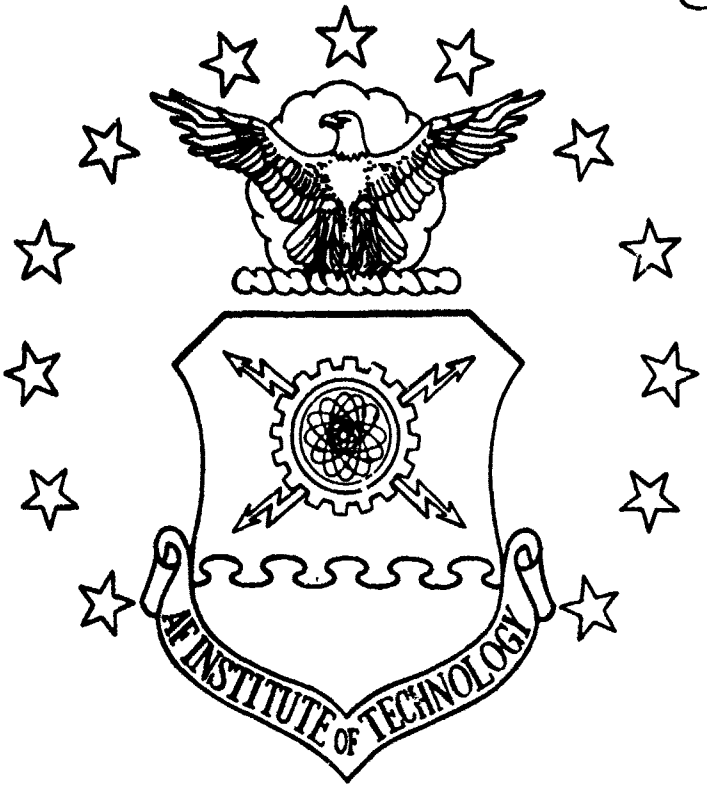

STATISTICAL EVALUATION OF THE EFFECTS OF SHOULD COST ON CONTRACT NEGOTIATIONS FOR AIR FORCE AND ARMY WEAPONS SYSTEMS

David V. Conway, 1Lt, USAF
Michael J. Howenstine, 1Lt, USAF

LSSR 114-83

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Wright-Patterson Air Force Base, Ohio

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: LSSR 114-83	2. GOVT ACCESSION NO. A135567 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): STATISTICAL EVALUATION OF THE EFFECTS OF SHOULD COST ON CONTRACT NEGOTIATIONS FOR AIR FORCE AND ARMY WEAPONS SYSTEMS	5. TYPE OF REPORT & PERIOD COVERED: Master's Thesis
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): David V. Conway, First Lieutenant Michael J. Howenstine, First Lieutenant	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: School of Systems and Logistics Air Force Institute of Technology, WPAFB OH	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Department of Communication AFIT/LSH, WPAFB OH 45433	12. REPORT DATE: September 1983 13. NUMBER OF PAGES: 82
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Approved for public release IAW AFR 190-17.

LYNN E. WOLAVER
Dean for Research and Professional Development
Air Force Institute of Technology (ATC)
Wright-Patterson AFB OH 45433

15 SEP 1983

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Should Cost
Cost Analysis
Cost
Acquisition
Statistics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Thesis Chairman: Stanley A. Leszczuk, Major, USAF

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This research effort is a statistical comparison of the percentage cost reductions during negotiations for contracts in which Should Cost was used and contracts where conventional cost estimating techniques were used. In addition, Should Cost contracts from the Air Force are compared with Army Should Cost contracts to detect any difference between the two diverse applications of the concept. Three hypotheses are tested. The first two are designed to determine if Should Cost has resulted in significant cost reductions for Air Force or Army acquisitions. The third attempts to detect any difference in the effectiveness of Air Force and Army Should Cost efforts. A Wilcoxon and a Mann-Whitney test both show no substantial increase in percent cost reductions during negotiations resulting from the Air Force's application of Should Cost. Army Should Cost analyses, on the other hand, seem to yield positive results, though the data available was insufficient to permit a quantitative test. Additionally, a Mann-Whitney test indicates that Army Should Cost analyses yield better results than those conducted by the Air Force.

LSSR 114-83

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A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degrees of Master of Science in Systems Management

and Master of Science in Logistics Management

By

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MASTER OF SCIENCE IN SYSTEMS MANAGEMENT
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MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
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DATE: 28 September 1983

Major, USAF
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ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the following people for their help and patience in the development of this thesis. First, to Major Stanley Leszczuk, our advisor, who kept us on the right track while allowing us enough freedom to call this work our own. Second, to Major Paine in the ASD Pricing Division, who provided us with Air Force Should Cost data. Lt. Howenstine would like to give special thanks to his wife, Gina, for her understanding and encouragement. Finally, thanks to the Air Force for giving us another opportunity to excel.

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CHAPTER 1

INTRODUCTION

In the last two decades, the Department of Defense (hereinafter referred to as DOD) has experienced a tremendous increase in the amount of spending for procurement of military hardware. Indeed, the amounts are difficult for the "average" individual to comprehend. The following table shows expenditures for durable military equipment as reported by the United States Bureau of the Census (29:357):

Year	Expenditures (In billions of then-year $)
1975	13.7
1976	14.3
1977	16.8
1978	17.8
1979	21.7

This equipment included such items as aircraft, ships, missiles, sacellites, and other minor and major weapon systems. This increasing spending trend is expected to continue in light of recent proposals to expand and modernize the military forces of the United States.

Unfortunately, it appears that not all of that money is being used as effectively as the taxpayers might desire. According to the chief executive officer of the Northrop Corporation, the General Accounting Office found that 80 percent of the country's past major weapon systems procure-

ment programs incurred overruns. In fact, some of the programs' costs increased more than 200 percent over the initial targets (19:482).

These overruns resulted from a variety of causes including inflation, changes in defense priorities and policies, technological changes, design changes, and mismanagement. Of course, some cost overruns, such as those caused by changes in defense priorities, are not a result of problems in the acquisition process; but some of the excess costs may be attributable to the way in which weapon systems are procured. Inefficiency on the part of the government and on the part of defense contractors may be sources of some cost overruns. These overruns can be minimized. To do so, however, will require some fundamental changes in the way weapon systems are acquired.

Concern over unwieldy costs within DOD permeates even the highest levels of government. When Mr. Frank Carlucci became the Deputy Secretary of Defense, he found individuals at all levels of the DOD who were bothered "with the cost of acquisition, particularly the overhead and indirect costs, and with our inability to estimate costs realistically [3:56]." In fact, his observations prompted him to write:

> At the top of my list of problems in the DOD, and the Defense Industry, is excessive cost--both from the standpoint of what we get from the dollars we spend and what we spend that the critics think is unnecessary. Some cost increases are unavoidable,

> and we must face up to factors such as inflation, advances in the state-of-the-art, and unavoidable changes in production schedules. However, we will continue to work hard to cut back on those costs which can be controlled [6:109].

Mr. Carlucci's views are reflected in his 32 initiatives (see Appendix A) which were, in a large part, directed towards reducing acquisition costs (5:3). Perhaps concern about military spending and procurement activities is best reflected by the Honorable William Proxmire who stated that "anyone who believes we are getting our tax dollars' worth out of military spending is the real victim of enchanting illusion [30:2591]."

Given that there is a noticeable amount of consternation concerning DOD spending, the government must continue trying to improve its procurement techniques to reduce spending and eliminate inefficiency. Traditional techniques of weapon system acquisition use historical cost figures as a basis for determining what new weapons systems should cost. After taking into consideration such factors as inflation, historical cost trends, and design changes, the government formulates a basis for negotiation. Unfortunately, this method of doing business perpetuates and multiplies the effects of wasteful and expensive contractor practices (13:5); but the elimination of this procurement approach is sure to meet with opposition from the defense industry. Dr. J. Ronald Fox, in his book Arming America: How the U.S. Buys Weapons, stated:

> Our current approach to pricing results in rewarding contractors for inefficiency. Typically profits are based on cost, resulting in reverse incentive to cost reduction. When the government is unable to determine how much a weapon system should cost, there is little pressure on the producer to reach the highest level of efficiency. His costs tend toward the government's upper budgeting limit. Past cost experience--often the most convenient standard for measuring efficiency--becomes a misleading indicator of future costs [11:80].

In order to obtain more hardware for the dollar, a number of innovations have surfaced. Some of the techniques the government utilizes to achieve cost reductions include Piecost, Cost/Schedule Control Systems Criteria, Multi-Year Procurement, Award Fee, Design-to-Cost, and Integrated Logistics Support (4:45-55). Another much publicized technique is known as "Should Cost". There is optimism that this approach can generate greater returns for each tax dollar spent. In 1973, the former Comptroller General of the United States, Elmer B. Staats, stated, "there is great potential for the government to benefit from the proper application of Should Cost concepts [30:2551]." Additionally, Lt. Gen. H. H. Driessnack noted that Should Cost provided a mechanism to keep new weapon system costs within allowable limits (8). Should Cost received probably its strongest indorsement from General Robert T. Marsh in January of 1983. At that time, General Marsh, Commander of Air Force Systems Command, stated his intent to utilize Should Cost as part of his "war on costs" to control areas which have historically shown, or are now

thought to have, a high probability for dramatic changes during the life of the cost estimate (1:8).

Should Cost

Definition

The Should Cost idea is officially defined in AFP 70-5 as:

> A technique of contract pricing that employs an integrated team of government acquisition, contract, administration, audit, and engineering representatives to conduct a coordinated, indepth cost analysis at the contractor's or subcontractor's plants. The objective is to identify uneconomical or inefficient practices in the contractor's management and operations and to quantify the findings in terms of their impact on cost. The result is the development of a realistic price objective that reflects reasonably achievable economies and efficiencies [31:1-1].

This definition is almost identical to that found in the Defense Acquisition Regulation. In more concise terms, "Should Cost is the determination of the amount that a product ought to cost, not will cost, based on attainable efficiency and economy of operations [14:13]."

Concepts

To arrive at these standards of efficiency and economy, a Should Cost team is assembled by the buying activity to investigate the various functions of a contractor's operations. These functions are usually broken down and categorized into three main functional areas: manage-

ment systems; purchasing and pricing systems; and engineering, technical, and manufacturing systems. By having inefficient contractor practices identified for them, government contract negotiators may be in a position to show potential contractors where cost reductions could be realized. The DOD can then be more confident it is paying for the hardware it receives, and not financing wasteful contractor operations. For example, a Should Cost analysis may uncover manufacturing operations in which excessive manual labor hours are applied or required. By eliminating this particular practice, DOD will save money not only through fewer direct labor hours paid for, but also through a lower allocation of overhead, which is usually calculated on a per-direct-labor-hour basis. In addition to the benefits to the DOD, the identification and correction of inefficiencies can help to improve the competitive position of the contractor. A more efficient operation means, basically, that less input is required to achieve a given level of output, or that more output can be achieved with a given level of input. A contractor who eliminates inefficiencies identified by government Should Cost analyses can reduce expenses, and thus increase his bottom line. The government, by performing Should Cost analyses, in effect assumes the role of consultant. The astute reader will probably recognize that accomplishing a thorough Should Cost analysis can be expensive. Trained personnel must spend many

man-hours in the contractor's plant reviewing his management and production practices.

Each of the three functional areas previously mentioned is usually analyzed by a separate, specialized team. Some of the typical activities each team investigates within the functional areas are as follows (36:35):

> Management Systems - searches out areas of duplication and overstaffing; develops interview techniques for all team members to assist in finding the areas of greatest potential savings.
>
> Purchasing and Pricing - reviews and evaluates usage factors, contractor's purchasing system, warehousing distribution, inventory control, make-or-buy, vendor management, scrap control, and various costing factors; prepares a final report for each task assigned; computes price objectives.
>
> Engineering, Technical, and Manufacturing - evaluates direct and indirect labor, labor standards, wage and salary scales; evaluates fabrication, assembly, testing, and inspection standards; evaluates costing factors; evaluates variance analysis and productivity standards.

The specific activities each team analyzes will be dictated according to circumstances. The Should Cost concept is not standardized to the point where all teams are identical and accomplishing cookbook procedures. However, the following skills are generally needed on a Should Cost team (31:42):

(1) Industrial Engineering
(2) Production Engineering
(3) Design Engineering
(4) Quality Assurance
(5) Accounting
(6) Auditing
(7) Pricing
(8) Management Analysis
(9) Mathematics or Statistics

Because each Should Cost team is tailored for the job at hand, the time, cost, and personnel requirements vary. One study conducted by the United States Army stated that the team size is usually about 20 people and that a thorough Should Cost analysis may require three to four months from initiation to completion (2:43). In a paper done for the Aeronautical Systems Division, USAF Major Gerald Heuer stated that "a typical [Should Cost] study would pass through . . . seven phases [17:213]." He went on to say that several months are usually required to complete a study, of which six to eight weeks are actually spent at the contractor's facility (17:212-213). Dr. Herbert Hoehl, Professor of Procurement Management at the Air Force Institute of Technology, reported that the teams may consist of anywhere from 10 to 40 personnel (18:49). These figures serve to highlight the fact that Should Cost studies involve significant effort and cost. In general, therefore, Should Cost should be applied only to major procurement efforts where the potential savings may outweigh the costs.

In addition to the costs of the studies, there is another potential drawback to application of Should Cost. By its very nature, the Should Cost method requires an intrusion by outsiders into a contractor's facility. As such, it may be criticized as impinging upon the contractor's private, internal affairs. Accordingly, as one Air Force price analyst has pointed out, the DOD may be told to either

accept the contractor's proposal or take its business elsewhere (10:136); but Mr. Gordon Rule, former assistant to the head of the Naval Materiel Command, replied to those types of criticisms in the following manner:

> The "Should Cost" Method of pricing must not be construed as an attempt on the part of the government to tell a contractor how to conduct his operation. If, for example, a contractor wishes to conduct a patently inefficient operation with excess indirect employees, poor estimating, labor that consistently fails to meet standards, lack of proper competitive subcontracting, abnormal spoilage and rework, etc., that is his business. It is the government's responsibility, however, not to pay taxpayer's money for demonstrable inefficiencies in the manufacturing process of a sole source supplier, regardless of the quality of the ultimate product [10:144].

It is not enough that the government select the most advantageous proposal. Should Cost analysis attempts to ensure that as little waste as possible is incurred in system acquisitions.

Assumptions

The preceding review of the Should Cost concept indicates that use of this acquisition technique requires some explicit assumptions be made. They are as follows (2:42):

- Whether due to complacency on the part of contractors, the government, or both, defense contractors have generally become inefficient producers.

- Defense contractors' proposals are high relative to the price that would prevail if they were efficient producers.

- Government analysts are better trained, more knowledgeable, more objective and/or more dedicated to achieving more for the defense dollar than are their counterparts in the defense industry.

- Government analysts conducting Should Cost studies will identify inefficiencies and use the findings to support government contract negotiating positions.

- Should Cost studies will improve the weapons acquisition process by achieving lower costs.

Past Studies and Results

Overview

The first Should Cost study took place in 1967 at Pratt & Whitney and was conducted by the Navy. It was initiated when the estimated cost of each F-111B engine, the TF-30, rose from an original estimate of $273,910 to $900,000 (10:138). These figures represent nominal increases over the five-year period from 1962 to 1967. However, even allowing for inflation, which was relatively low during the mid-1960s, this was a substantial overrun. Since that time, Should Cost has received a great deal of publicity praising the technique as the panacea for the government's out-of-control acquisition activities. However, analyses of the results of some of the procurement efforts involving Should Cost have yielded mixed results. In this section, some of those analyses will be considered. Other Should Cost topics discussed are effects of timing on studies, criteria for studies, and size of the teams.

Findings

The objective of Should Cost, as stated by the U.S. Air Force, is to provide the DOD with empirically derived, quantitative data. The data are then used for guidance in contract negotiations (31:2-1). This objective proved to be a common factor among the literature reviewed. Because of the pragmatic nature of the data, the Should Cost concept is highly oriented toward the final product and applied production processes of the vendor. As such, the amount of cost reduction in a procurement directly attributable to the Should Cost study is dependent upon the acquisition phase in which the study is completed. Obviously, as more design changes are incurred by a product, its production processes and materials will also change and the validity of the study will decrease. A study done in the latter stages of a system's life cycle will be subject to less technological and design uncertainty than a study conducted in the initial stages. Thus, more effective measurement and evaluation of the input/output relationships can be realized (20:13). Consequently, the later studies will better demonstrate the possibilities of achieving reduced costs. Figure I is a graphical representation of this concept (14:15). The exact shape of the curve in Figure I is unknown, but the approximation shown here indicates that contract negotiation should occur as late as possible to reap the full benefits of a Should Cost study.

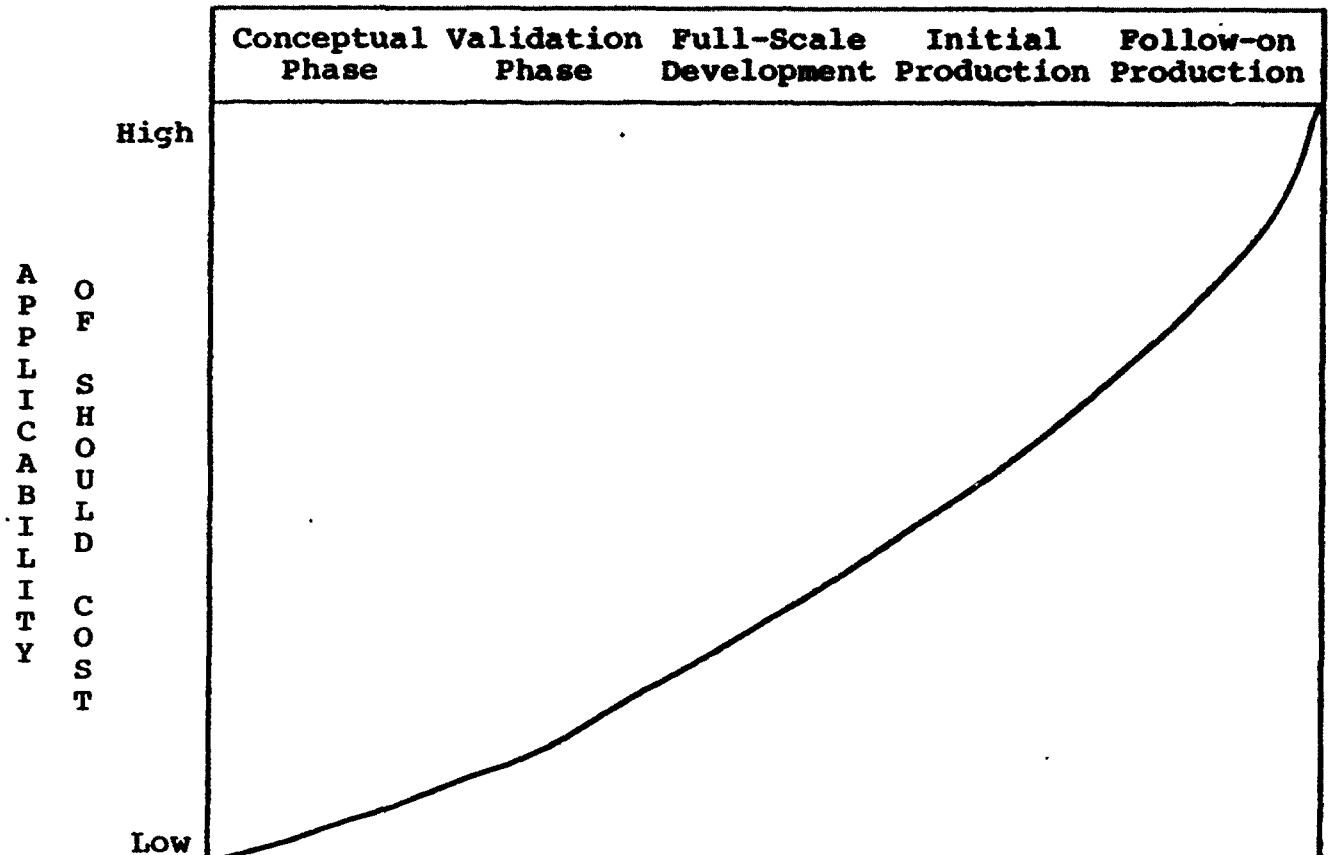

Figure 1. Applicability of Should Cost as a Function of Technological Certainty

The timing of the study is not the only factor to consider before implementation. The expense required in conducting a Should Cost analysis should be of major concern. Various sources indicated the important role of the following criteria in determining Should Cost applicability (4:47; 7:21; 31:2-2):

- Is the program a major one of high dollar value?
- Does the contractor have substantial amounts of government sales?
- Does the contractor have a history of increasing costs?
- Will there be a significant number of follow-on production contracts?
- Is there adequate time for the study?

Army Materiel Command Pamphlet 715-7 states that a lack of adequate price competition (as in the case of a sole-source procurement) in contracting activities should be a requirement for Should Cost studies (34:2-1). This is based on the view that when multiple suppliers are available:

> There will be some form of price competition among suppliers. Furthermore, if price competition exists, efficiency of operations and reasonable price proposals are assumed to result [7:21].

This assumption is supported in the Defense Acquisition Regulation (35:1-337). However, not all analyses support this position. Dr. H. G. Hoehl proposes that once a "competitive contract is awarded, the contractor essentially becomes a sole-source supplier [18:49]." Mr. David Packard,

former Deputy Secretary of Defense, holds the following views on the virtues of contractor competition:

> I have great faith in the competitive free enterprise system; I believe it to be generally more efficient than government management. But, I have reluctantly concluded that where we have complex, expensive military systems, and where only one customer exists the leveling actions of the free market economy simply do not work [37:7].

It is clear that no consensus has been reached on this point. Perhaps investigation into the competitive versus noncompetitive question will resolve the dispute in the future.

When forming a Should Cost study team, one of the most difficult decisions to make is how many individuals to include. Most literature encountered advocates the tailoring of the team's size and composition to the task at hand. The U.S. Army advocates using an advance team to scout the contractor's facility to determine the team's requirements (34:3-5). On the Air Force side, Lt. Gen. Driessnack recently stated that large teams are not needed (8). Small teams could, he said, suffice for all studies. This "mini" team approach employed by the Air Force requires fewer people and less time. However, "experienced Army and Navy Should Cost team members claim that the Air Force is not performing Should Cost analysis, but rather an expanded pre-award survey [18:50]."

Industry seems to hold a point of view which agrees with the Air Force's. A study by R. W. Haight, Lt., USN, found contractors generally preferred small teams made up

of "independent consultants [in order to] remove any parochialism that would exist had the team been made up of personnel from the activity responsible for the procurement [14:31]." That particular study also indicated that a team of this nature would foster more cooperation between the team and contractor and reduce the contractor's support requirements. Haight clearly indicated that the contractors made no mention of the fact that small teams are easier to manipulate than large teams (14:32).

Perhaps a systems approach to the question of team size would be helpful. This approach identifies the desired output in terms of depth of analysis and scope of study. The processes used to derive the outputs will consist of input factors chosen with respect to time, personnel, expertise, and funds available. Inputs are also needed from previous studies of similar tasks to evaluate the composition of teams judged "successful" in the past.

Another point to consider when fielding a Should Cost team is who will provide the personnel. The Government Accounting Office (GAO) concluded that analyses should be "performed by procuring activities as part of the pre-award analysis [12:28]." Another study concluded that the GAO should conduct all Should Cost studies (7:48). Still another study recommended that Air Force Should Cost responsibilities be assigned to a single office: Air Force Contract Management Division (36:124). Finally, Lt. Robert

Seiwart, USA, proposed that Should Cost studies should be conducted by an outside firm or by a joint industry/government team (25:40). These differing views emphasize the degree of uncertainty in the application of Should Cost, but perhaps there is no one best agency to oversee Should Cost. The need to tailor a Should Cost study to each situation may well extend to the assignment of responsibility for the study.

Since the initial Should Cost study at Pratt & Whitney in 1967, numerous additional studies have been performed. Between 1973 and 1979, the Army conducted 89 studies, the Air Force 37, and the Navy three (one of which was conducted by consultants)(18:50). Unfortunately, few in-depth studies analyzing the costs versus the benefits of the Should Cost technique have been performed. There seems to be a great deal of discussion and very little actual empirical analysis.

One particular area that has attracted some limited attention is the cost of conducting a Should Cost study. One of the most expensive studies involved an investigation into the MK-48 torpedo for the Navy (7:19). The estimated price tag in that case was approximately $4 million. This illustrates the potential high costs that may be incurred in performing Should Cost analyses. This factor should be considered in light of potential cost savings before initiating a study. Joseph R. Weis, in a research report for

the Florida Institute of Technology, reviewed 30 Should Cost studies conducted by the Army from 1973 to 1977. The results are encouraging for proponents of the technique. Costs for the studies ranged from .2 to 17.7 percent of the procurement savings attributed to Should Cost. Of the 30 Should Cost studies reviewed, the most expensive cost the Army $201,672 to perform. The resultant savings in that study were $5.4 million (37:15). Most financiers would agree that such a large net return is quite impressive. A summary of the 30 contracts in Weis' study shows the following (17:217):

Proposed Total Contract Costs	$1,473.9 million
Negotiated Total Contract Costs	-1,239.8 million
Total Reduction	234.1 million
Historical Savings	-86.4 million
Should Cost Savings	147.7 million
Cost of Should Cost Studies	-1.6 million
NET SAVINGS	146.1 million

The historical savings were obtained from comparison of previous procurements of the same type with each Should Cost study.

Dr. Hoehl investigated 44 Army contracts negotiated between 1975 and 1979 for which Should Cost analyses were performed. He found a difference of $691 million between the proposed and negotiated costs. The costs of the Should Cost studies was $7.5 million. No data were obtained to allow comparison of these savings with what might have been realized using other acquisition techniques. In a 1974 study done for the Defense Systems Management School, 23

Should Cost efforts conducted by the U.S. Army were analyzed(22:14). A total reduction of $141.1 million was achieved in negotiations. Historical data indicated that conventional cost analysis techniques used on acquisitions of similar size and type would have resulted in savings of $52.5 million. Of the $141.1 million, $88.6 million was attributed to the use of Should Cost. The application of Should Cost analysis more than doubled the normal cost reduction achieved in negotiations.

Dr. Hoehl reviewed 37 Should Cost studies conducted by the Air Force between 1973 and 1979. He found that the Air Force saved $565 million during contract negotiations while spending only $1.4 million for the Should Cost studies (18:50-55). In the Defense Systems Management School study cited earlier, five Air Force Should Cost efforts were analyzed. A total cost reduction of $131.1 million was achieved in negotiations, of which $65.3 million was attributed to Should Cost efforts. Once again, more than half of the total reduction in costs realized during contract negotiations resulted from the application of Should Cost.

In a speech at the Air Force Pricing Conference on 13 July 1982, Lt. Gen. H. H. Driessnack presented the following data:

	Should Cost	Other Techniques
Number of contracts	12	15
Initial proposal	$613.2M	$539.2M
Negotiated price	512.0M	506.4M
Dollar reduction	101.2M	32.8M
Percent reduction	16.5%	6.1%

The percent reductions from initial proposal to final negotiated price for those contracts in which Should Cost was used are almost three times as high as the percentages for non-Should Cost contracts. Unfortunately, no data were available as to when the studies were conducted. At least on the surface, the Should Cost studies appear to be providing a more effective means of negotiating cost reductions.

In 1976, a statistical analysis was conducted on 30 U.S. Army Should Cost studies. The researchers attempted to determine whether or not a relationship existed between the prices initially proposed by contractors and the size of the difference between the initial proposal and the final negotiated price. The coefficient of determination (R-squared) was calculated to be .9686. (A value of 1.0 for R-squared indicates a perfect linear correlation.) When the initial proposals were compared with the corresponding differences between proposed price and Should Cost estimate, R-squared was found to be .9403 (9:36). No significant relationships were found, however, when the initial proposals were compared with the differences between proposed price and negotiated price and between proposed price and Should Cost estimate as a percentage of the initial proposal (9:39). (Values of R-squared were 0.0087 and 0.0161 respectively.) The study revealed that the percent reductions "seem to have been relatively constant within a certain range [9:26]." The constant percentage would account

for the linear relationship noted above. As the contractor proposals increased, so too did the absolute dollar difference between the proposals and the Should Cost estimates and the negotiated prices. It should be pointed out that the statistical analysis did not try to consider the money that might have been saved had Should Cost not been used.

Lt. Col. William E. Schaefer and Major Roy F. Birkhead conducted another study at the Air Force Institute of Technology in 1975. They compared four completed contracts negotiated using Should Cost with four previous year buys for the same weapon systems where conventional cost analysis techniques were used. Schaefer and Birkhead attempted to determine if there was any difference between the actual cost outcomes on contracts in the two groups (24:11). One of their five tests compared the proposed cost to negotiated cost for the Should Cost and non-Should Cost contracts. They found that, at the .05 significance level, the null hypothesis of no difference could not be rejected (24:57). No significant difference could be found between the percent changes from proposed to negotiated costs. While interesting, these results are somewhat suspect due to the sampling methods and statistical techniques used.

In performing their analysis, Schaefer and Birkhead obtained a convenience sample containing four Should Cost and four non-Should Cost contracts. They then employed the

Paired t Statistic to test their hypothesis. The use of a parametric test, such as the t test, requires that several basic assumptions be made. For instance, the populations must be assumed to be normally distributed, or the samples must be sufficiently large random samples to apply the Central Limit Theorem. The populations from which Schaefer and Birkhead drew their samples may be normally distributed, but there is no real basis for assuming so. Their samples certainly were not random, and a sample size of four is not large enough to justify invoking the Central Limit Theorem. Therefore, the small samples, the way in which they were chosen, and the fact that a parametric test was used all call question to the validity of the results obtained by Schaefer and Birkhead. Their conclusions should, by no means, be discarded. However, they should be treated cautiously.

Summary of Past Studies

It is evident that much more work remains to be done. The number of studies concerning costs and savings is scant, and there is substantial disagreement. In the analysis of Schaefer and Birkhead, the small sample size could cast doubt on the validity of the results. Additionally, no studies were encountered that were concerned with the effects different types of contracts might have on the effectiveness of Should Cost. For example, do contracts such as

Firm Fixed Price and Fixed Price Incentive Firm show different savings than other, cost type contracts. There is disagreement over whether Should Cost is applicable to sole-source and/or competitive procurements. Investigation of the effects of the acquisition phase in which Should Cost analyses are conducted is also needed. Finally, there is no concurrence among analysts as to the agency which should conduct Should Cost studies. Without further investigation into these areas, the real worth of Should Cost cannot be determined.

Problem Statement and Objective

Given the Should Cost findings mentioned in the preceding literature review, there remains some doubt as to whether there are actual cost savings realized by the DOD through the application of Should Cost. The objective of this analysis of Should Cost contract data was to determine if alleged procurement savings are significantly greater than savings realized through the use of other acquisition techniques.

Research Hypotheses

The following three research hypotheses were investigated in this study:

Hypothesis 1

There is no significant difference in the percent cost reduction during negotiations between Air Force contracts involving Should Cost and those where Should Cost is not used.

Hypothesis 2

There is no significant difference in the percent cost reduction during negotiations between Army contracts involving Should Cost and those where Should Cost is not used.

Hypothesis 3

There is no significant difference in the percent cost reductions during negotiations between Air Force and Army acquisitions that employ the Should Cost technique.

CHAPTER 2

METHODOLOGY

This chapter contains an explanation of the data collection and statistical test techniques used in this analysis.

Data Collection

The first two hypotheses stated in Chapter 1 are concerned with determining whether or not there is a significant difference in percent cost reductions during negotiations for Should Cost and non-Should Cost contracts. The statistical tests employed here were the Wilcoxon Signed Rank Test for comparing paired samples from two populations, and the Mann-Whitney Test for comparing independent samples from two populations. The third hypothesis involves comparing Should Cost contracts for the Air Force with those for the Army to determine if either of the two diverse applications of the technique provide better results. The Mann-Whitney Test was again applied here. The reasons for using these particular tests will be discussed later in this chapter. To perform the tests, samples must be drawn from two populations. The populations from which samples were drawn in this analysis differ for each hypothesis test.

For Hypothesis 1, one population is made up of all weapon system acquisition contracts entered into by the Air Force since the Should Cost technique was first used. The second population includes only those contracts in which Should Cost was employed. The populations for Hypothesis 2 are the same as those for Hypothesis 1 except that they contain only Army procurement contracts. For Hypothesis 3, one population contains Air Force contracts for which Should Cost was used, and the other contains Army contracts where Should Cost was used.

DOD contracts generally fall into one of two categories: fixed-price and cost reimbursement. In a fixed-price agreement, the cost of a particular system is agreed upon by both parties. In addition, some fixed profit amount or some share arrangement for any reductions in cost is negotiated. This type of contract is usually used when there is little technical risk involved; when production methods and design have been established. The types of fixed-price contracts dealt with in this study are firm fixed price (FFP) and fixed price incentive firm (FPIF). A FFP contract is:

> An agreement to pay a specified price when the items specified in the contract have been delivered and accepted. The price for the original work is not adjusted afterward, regardless of the contractor's actual cost experience [35:131].

There are, of course, exceptions for changes in accordance with the change clause and other applicable contract

clauses. A FPIF contract is used where contractor risk cannot be reduced to a level acceptable for use of a FFP contract (35:132). The basic elements of the FPIF contract are target cost, target profit, ceiling price, and share ratio. The share ratio specifies the portion of any cost increase above target cost which the government will pay or the portion of any cost decrease the government will receive.

Cost reimbursement contracts are used in situations characterized by high risk. For example, this type of contract is often used in the area of research and development. Cost reimbursement contracts may be used when specifications are incomplete or when there is doubt about whether the contract can be successfully accomplished (35:134). The common factor here is a high degree of risk. Contract costs cannot be accurately estimated. The contractor in this case is reimbursed for all costs incurred. In addition, the government pays some fee to the contractor. The fee may be a negotiated target amount, or may be variable according to some incentive schedule. Under the variable, or incentive plan, the contractor receives a larger fee when costs are reduced.

The inherent differences between the two types of contracts, fixed-price and cost reimbursement, make it likely that contract type will have some effect on price negotiations. Therefore, it is desirable to separate con-

tract data based on the type of contract involved. Unfortunately, Should Cost is usually applied only to contracts for production of weapon systems which have already been manufactured in the past and for which design and production processes have already been established. As has been pointed out, these procurements usually lend themselves to the use of fixed-price contracts. In fact, all of the data obtained involved either FFP or FPIF contracts. Therefore, no basis for comparing the relative benefits of Should Cost for fixed-price versus cost reimbursement contracts was available to the researchers.

The data collected consist of the contractor's proposed price (or target price) and the negotiated price (or target price). Contractual changes affecting both price and specification will not be taken into account. The concern of this research is with the price reduction during initial award negotiations, and how the use of Should Cost affects it. There may be, and usually are, many contract changes during the life of weapons systems. These changes are normally accompanied by increases in the cost of the systems involved. It is not the purpose of this study to attempt to determine the effects of Should Cost on contract changes in out years. For this reason, design and price changes made after the contracts were negotiated are not considered.

Sampling Method

The data gathered for this analysis consists of a convenience sample. A convenience sample is simply a sample containing data which is available to the researcher. The nature of a convenience sample generally renders it unrepresentative of the population from which it is drawn. Therefore, the results may be biased (16:256). Still, such a sample is not without merit. It may provide evidence so overwhelming it is unnecessary to use more sophisticated sampling techniques (23:177).

A convenience sample was used in this study because of the general lack of historical contract data. Neither the Air Force nor the Army has established a centralized repository for data on Should Cost contracts. The search for data was restricted to the U.S. Army Materiel Development and Readiness Command (DARCOM) and its subcommands, and the U.S. Air Force Systems Command and its product divisions. These entities are the research and development and procurement mechanisms, and the center of nearly all Should Cost activities in their respective branches. In many cases, the organizations queried either did not maintain or were reluctant to search for the type of data needed to perform this analysis.

The search for data was hampered by another factor which necessitated the use of a convenience sample. In

order to perform the Wilcoxon Test for Hypotheses 1 and 2, samples containing matched pairs of observations were needed. To provide for some natural pairing of observed values, the researchers decided to arrange the data such that each contained one Should Cost contract and one non-Should Cost contract for different production lots of the same weapon system. For an item to provide useful data, therefore, it had to be characterized by at least one Should Cost acquisition and at least one "conventional" acquisition. In the Army, a Should Cost analysis is performed on items "lacking adequate price competition and exceeding $25 million in contract price [32:2]." This implies that an item must have reverted from a competitive procurement to a sole-source procurement or vice-versa in order to provide the required matched pair. This does not normally occur for items procured in DOD. Therefore, the data available was somewhat limited. This fact may call question to the generalizability of any results obtained in this analysis.

Ideally, the data used in this study should be differentiated only by the presence or absence of a Should Cost analysis for Hypotheses 1 and 2, or by the method of analysis, either Air Force or Army, for Hypothesis 3. As the researchers discovered, however, this is rarely the case. Many factors come into play during the contract negotiation phase, and these factors often change from one

contract to the next. Some of the factors affecting negotiations include:

- contractor
- the people involved in negotiations
- number of units acquired
- modifications distinguishing one model from another
- changes in production methods
- upgrading production facilities
- method of overhead cost allocation
- increased experience level of production personnel or personnel turnover
- economic conditions influencing costs of materials
- availability of substitute items

Some of the factors above can be controlled. By comparing data from different production lots of the same weapon system, the problem of differing contractors can be eliminated. In addition, the same people are often involved in negotiations, and the method of overhead allocation usually remains the same. Where there was a choice, contracts were chosen such that the quantities purchased were as close as possible. Since Should Cost concepts have generally only been applied to high cost contracts for established systems, there are not generally a great many substitute items available. The fact that the data used in this study is made up of the percent reduction in price during negotiations should help control for any change in economic conditions.

The other factors listed above cannot be controlled in a study employing a convenience sample as this one does. They therefore must be considered moderating variables in this analysis.

Statistical Analysis Method

As was stated previously, the Wilcoxon Signed Rank Test and the Mann-Whitney Test were used in this study. These tests come from a relatively new class of statistical methods called nonparametric, or distribution-free methods. There are three major reasons in this case for using nonparametric techniques. First, the assumption cannot be made that the samples are drawn from normal populations. This is so for a number of reasons:

1. The populations include a variety of weapon systems representing a non-homogeneous group.
2. Contracts are for varying quantities.
3. Defense contractors are not a homogeneous group.
4. The use of Should Cost studies has been limited to high cost contracts selected at the discretion of the procuring organization. (This has recently changed in the Army where Should Cost is now mandated for contracts over a certain dollar threshhold.)

The second reason for the use of a nonparametric test is the method of sample collection and the size of the samples. The Central Limit Theorem says that if random

samples of sufficient size are used, they can be assumed to be normally distributed regardless of the distribution of the parent population. The samples in this study, however, are convenience samples, and are not generally large enough to invoke the Central Limit Theorem.

Third, the variances for the populations cannot be assumed to be equal. This is true for basically the same reasons as those listed above. Snedecor and Cochran indicate that "when samples come from populations of different types", their variances should be assumed to be different (27:96). The researchers felt that the above factors warranted the use of nonparametric methods in analyzing the data. While these techniques may require more care in interpreting results, the more robust nature of the distribution-free tests makes them the logical choice in this study.

According to a text written by Larry E. Richards and Jerry J. LaCava, three conditions should be satisfied before the Wilcoxon test is used (23:348). First, there should be a natural pairing of observations. Second, the data should be at least interval level data; and third, data should be produced such that tied values of the paired differences are not very likely. An attempt was made to collect data in such a way as to allow the formation of matched pairs, each containing a Should Cost and a non-Should Cost contract for the same weapon system. This, it

was hoped, would provide some natural pairing of the observations. The data are in the form of percentages--specifically, the percent differences between proposed and negotiated prices. It is therefore considered to be ratio level data. Because the data was derived as a percentage, ties are very unlikely.

As stated before, in using the Wilcoxon Signed Rank Test, the data are arranged in matched pairs. Each pair contains one contract in which Should Cost was used and one in which it was not. Looking then at the percent change from contractor proposal to negotiated price, the difference between the percentages for each pair is computed. The absolute values of these differences are then ranked from lowest to highest. The test statistic becomes the smaller of the rank sums of either the positive or the negative differences.

The sums of the ranks for the positive and negative differences are obtained separately. These sums form the basis for testing the null hypothesis Ho: Rank Sum (+) = Rank Sum (-). The null hypothesis is that the populations from which the two samples are drawn are identical. If this is indeed the case, the population positive and negative differences should be symmetrically distributed about a mean of zero (15:525). If the smaller of the two rank sums, conventionally known as Wilcoxon's t statistic, is equal to or less than the critical value of t, the null

hypothesis can be rejected. In testing Hypotheses 1 and 2 in this analysis, if the rank sum of the positive differences is equal to or less than the critical value, it can be concluded that there is some significant increase in percent cost reductions during negotiations when Should Cost is applied. If, however, the null hypothesis cannot be rejected, the percent cost reductions must be assumed to be equal regardless of whether Should Cost is used or not.

As a further test of Hypothesis 1, and in analyzing the data for Hypothesis 3, the researchers employed the Mann-Whitney Test. Much of the data obtained from the Air Force could not be used in the Wilcoxon Test. Therefore, the researchers decided to perform a second test, the Mann-Whitney, which would allow inclusion of the entire set of available data. In addition, it was decided that it would be difficult or impossible to arrange data in matched pairs in order to perform a Wilcoxon Signed Rank Test for Hypothesis 3. The inherent differences in the types of weapons procured for Army and Air Force use are too great to permit any natural pairing of observations. Therefore, the Mann-Whitney Test is used here. The first step in the Mann-Whitney Test is to rank all observations from the two independent samples from smallest to largest. Values are assigned to each observation according to its rank, and rank sums are computed for both samples. These rank sums,

termed Ta and Tb form the basis for computing the test statistic, U. If the populations are identical, the rank sums for two samples will tend to be equal (21:783). However, if some difference exists between the two populations, there will be a tendency for one of the rank sums to be larger than the other. Two values for the test statistic are computed in the following manner:

$$Ua = n_1 n_2 + \frac{n_1(n_1+1)}{2} - Ta$$

$$Ub = n_1 n_2 + \frac{n_2(n_2+1)}{2} - Tb$$

Large values for the rank sums lead to small corresponding values for the U statistic. Therefore, to determine if population A is shifted to the right of population B, which implies that population A contains generally larger values, Ua would be compared to some specified value, Uo. If Ua is less than Uo, the null hypothesis of no difference can be rejected; and it can be concluded that population A is indeed shifted to the right of B. If Ua is greater than Uo, and Ub tests out similarly, the null hypothesis cannot be rejected. The populations must be assumed to be identical.

While the two nonparametric methods employed here are relatively easy to apply, and while they do not require the limiting assumptions necessary for parametric tests, there are some disadvantages to their use. Because the tests involve the use of ordering or ranking as opposed to

the actual numerical values of the observations, some information may be lost (15:519). While it may be possible to determine if one population is shifted to the left or right of another, the magnitude of the shift is not known. For this reason, it was not possible in this analysis to take the incremental funds expended for Should Cost studies into account. The researchers decided, however, that the nature of the populations and the method of sample collection mandated the use of a distribution-free technique.

CHAPTER 3

DATA ANALYSIS

This chapter presents the data obtained and the statistical tests performed for each of the three research hypotheses stated in Chapter 1. Part 1 concerns Air Force data used to test the validity of Hypothesis 1. Part 2 presents Army data for testing Hypothesis 2, and Part 3 is concerned with the data from both the Air Force and the Army used to check the validity of Hypothesis 3.

Hypothesis 1

> There is no significant difference in the percent cost reduction during negotiations between Air Force contracts involving Should Cost and those where Should Cost is not used.

All data collected on Air Force Should Cost procurements were obtained from the Pricing Division of Aeronautical Systems Division, Air Force Systems Command. Non-Should Cost contract data was obtained from the Aeronautical Systems Division Cost Library. Table 3-1 is a compilation of all data obtained on Air Force acquisitions. As stated in Chapter 2, this data lends itself to two basic types of statistical tests: a paired test and an unpaired test. The two tests used were the Wilcoxon Signed Rank Test and the Mann-Whitney Test. The Wilcoxon Test was performed in

an attempt to control for external factors which might cause some correlation between observations. The Mann-Whitney Test was also performed because arranging the data in matched pairs for the Wilcoxon Test meant that many observations had to be omitted.

Table 3-2 shows the data used for the Wilcoxon Signed Rank Test. This table contains a subset of the data presented in Table 3-1. Observations have been selected such that matched pairs can be formed. Each matched pair contains two contracts for the same weapon system, from the same contractor, with contract costs matched as closely as possible. Once these matched pairs are formed, the Wilcoxon Test can be performed as shown below.

Ho: Populations are identical

Ha: One population is shifted to the right or left of the other.

Reject Ho if the rank sum(+) or rank sum(-) is less than or equal to 3.*

*Critical values for each of the tests performed are taken from H.R. Neave's Statistics Tables. All are based on a two-tailed test with a .05 significance level.

The computations needed to perform the Wilcoxon Test are shown in tabular form below:

TABLE 3-1

SHOULD COST AND NON-SHOULD COST CONTRACTS FOR THE AIR FORCE

Contractor and Weapon System	Should Cost			Non-Should Cost		
	Proposed	Negotiated	% Reduction	Proposed	Negotiated	% Reduction
ITT ALQ-117	28,174,389	25,800,000	8.42	35,700,478	32,548,000	8.83
	20,477,063	17,625,000	13.93			
TI APQ 99/122	11,639,715	9,875,000	15.16	53,923,355	53,629,850	0.54
				1,955,450	1,955,000	0.02
Northrop F-5B/E	39,450,157	32,640,025	17.26	17,400,866	15,500,000	10.92
	19,092,921	16,220,828	15.04	149,611,515	133,050,000	11.07
	926,565,523	792,622,000	14.46	164,337,699	129,182,000	21.39
				141,272,708	126,755,568	10.28
				81,831,093	64,689,000	20.95
				107,494,077	87,857,838	18.27
				92,095,021	82,466,900	10.45
GE TF-34/ J-85/T-64 Engines	230,341,742	215,524,011	6.43	53,101,055	53,064,484	0.07
	182,249,871	169,205,265	7.16	57,330,651	57,326,137	0.01
				85,382,144	77,669,005	9.03
				204,065,600	188,717,333	7.52
Teledyne Ryan BQM-34	5,408,723	4,731,400	12.52	19,222,036	17,752,680	7.64
	7,604,470	6,587,564	13.37			
Cessna A-37B	19,099,037	16,520,000	13.50	6,059,432	5,622,012	7.22
				29,104,976	28,982,138	0.42
McDonnell-Douglas F-4G E/TF-15	81,062,525	74,800,000	7.73	298,059,783	281,995,000	5.39
	838,682,351	789,053,670	5.92	80,007,000	64,400,000	19.51

TABLE 3-1 (Continued)

Contractor and Weapon System	Should Cost			Non-Should Cost		
	Proposed	Negotiated	% Reduction	Proposed	Negotiated	% Reduction
Hughes	94,400,000	85,900,000	9.00	132,767,217	121,000,000	8.86
AGM-65	128,600,000	121,500,000	5.52	17,778,853	17,200,000	3.26
Maverick				71,753,539	68,301,000	4.81
				112,166,455	93,557,000	16.59

TABLE 3-2

MATCHED PAIRS FOR WILCOXON TEST
AIR FORCE DATA

Contractor and Weapon System	Should Cost			Non-Should Cost		
	Proposed	Negotiated	% Reduction	Proposed	Negotiated	% Reduction
ALQ-117	20,477,063	17,625,000	13.93	35,700,478	32,548,000	8.83
F-5B/E	19,092,921	16,220,828	15.04	17,400,866	15,500,000	10.92
	926,565,523	792,622,000	14.46	164,337,699	129,182,000	21.39
TF-34/J-85/T-64 Engines	182,249,871	169,205,265	7.16	85,382,144	77,669,005	9.03
BQM-34	7,604,470	6,587,564	13.37	19,222,036	17,752,680	7.64
A-37B	19,099,037	16,520,000	13.50	6,059,432	5,622,012	7.22
F-4G/E	81,062,525	74,800,000	7.73	289,059,783	281,995,000	5.39
AGM-65	128,600,000	121,500,000	5.52	112,166,455	93,557,000	16.59

TABLE 3-3

COMPUTATIONS FOR WILCOXON TEST

	% Reduction			Rank	
	Should Cost	Non-Should Cost	Difference	(+)	(-)
1	13.93	8.83	+ 5.10	4	
2	15.04	10.92	+ 4.12	3	
3	14.46	21.39	- 6.93		7
4	7.16	9.03	- 1.87		1
5	13.37	7.64	+ 5.73	5	
6	13.50	7.22	+ 6.28	6	
7	7.73	5.39	+ 2.34	2	
8	5.52	16.59	-11.07		8
			Sum	20	16

The reader will note that the lower of the two rank sums--that for the negative differences--is greater than the critical value of 3. Therefore, based on this sample, the null hypothesis cannot be rejected. It cannot be concluded that there is a significant difference between the two populations. However, as Table 3-3 indicates, the rank sum for the negative differences is affected significantly by two observations. Observations 3 and 8 both show percent cost reductions for the non-Should Cost contracts which may be unusually high: 21.39 and 16.59 percent, respectively. Since the data presented here represent a small convenience sample, there is a strong possibility that the distribution of the samples may not be representative of their populations. As an additional check, the entire set of data shown in Table 3-1 was used to perform a Mann-Whitney Test.

Table 3-4 shows the percent reductions and associated rank sums for all 38 observations. The Mann-Whitney Test is performed on the data in the following manner:

Ho: Populations are identical

Ha: One population is shifted to the right or left of the other.

Reject Ho if Ua or Ub are less than or equal to 106.

The test statistic for the Should Cost contracts, Ua, and that for the non-Should Cost contracts, Ub, are calculated as follows:

$$Ua = (15)(23) + \frac{(15)(15+1)}{2} - 332$$

$$= 133$$

$$Ub = (15)(23) + \frac{(23)(23+1)}{2} - 409$$

$$= 212$$

Again, neither of the two test statistics falls below the critical value. As was the case in the Wilcoxon Test, the null hypothesis cannot be rejected. There is no proof, based on the sample collected for this treatise, that there is a significant difference between the percent price reductions during negotiations for Air Force acquisitions in which Should Cost was employed and those in which it was not.

TABLE 3-4

AIR FORCE DATA FOR MANN-WHITNEY

Should Cost		Non-Should Cost	
% Reduction	Rank	% Reduction	Rank
8.42	17	8.83	18
13.93	29	0.54	5
15.16	32	0.02	2
17.26	34	10.92	24
15.04	31	11.07	25
14.46	30	21.39	38
6.43	11	10.28	22
7.16	12	20.95	37
12.52	26	18.27	35
13.37	27	10.45	23
13.50	28	0.07	3
7.73	16	9.03	21
5.92	10	7.52	14
9.00	20	7.64	15
5.52	9	7.22	13
		0.42	4
n = 15	332	5.39	8
		19.51	36
		8.86	19
		3.26	6
		4.81	7
		16.59	33
		0.01	1
		n = 23	409

Hypothesis 2

There is no significant difference in the percent cost reduction during negotiations between Army contracts involving Should Cost and those where Should Cost is not used.

In testing this hypothesis, the researchers were not as fortunate in obtaining data as was the case with the data in Part 1. In an effort to collect the required information, DARCOM Headquarters and each of its subcommands were contacted. Requests for data were made to the Should Cost coordinator of each organization. The data collected are presented in Table 3-5. These data were obtained from the following sources:

Weapon System	Source
Helicopter Engine	Troop Support and Aviation Materiel Readiness Command
Helicopter A	
Helicopter B	DARCOM Headquarters
Tow Missile	Missile Command

Most of the remaining subcommands of DARCOM did not have the requested information. One office that indicated it did have the data considered it proprietary contractor information and would not release it.

As Table 3-5 reflects, data collected included only six Should Cost contracts and seven non-Should Cost contracts. These contracts involved the acquisition of only four different weapons systems. Considering this and the method of sample collection, the researchers decided that any statistical test performed on these data would be incon-

TABLE 3-5

SHOULD COST AND NON-SHOULD COST CONTRACTS FOR THE ARMY

Weapon System	Should Cost			Non-Should Cost		
	Proposed	Negotiated	% Reduction	Proposed	Negotiated	% Reduction
Helicopter A	281.9M	238.8M	15.28	152.8M	139.8M	8.5
	265.9M	237.8M	10.57			
	283.3M	231.2M	18.39			
Helicopter B	947.3M	738.0M	22.09	116.4M	101.8M	12.5
				151.4M	142.6M	5.8
Tow Missile	4,159.0M	3,523.0M	15.29	2,591.0M	2,491.0M	3.9
				5,380.0M	4,689.0M	12.8
				4,958.0M	4,489.0M	9.5
Helicopter Engine	72.2M	38.4M	46.81	83.3M	75.9M	8.9

clusive at best; at worst, misleading. It was decided, therefore, that a qualitative assessment of the data might be the only viable option.

Looking at Table 3-5, it becomes apparent that the percent price reductions for Should Cost contracts are generally higher than those for non-Should Cost contracts. In fact, all but one of the contracts involving the use of Should Cost show higher percent reductions than 12.8 percent, which is the highest value for the non-Should Cost contracts. Additionally, when contracts for like commodities are compared, all Should Cost contracts show higher percent reductions. It would certainly be improper to assert that these small samples are representative of their respective populations, and a qualitative analysis of the data may not be statistically rigorous. However, it does appear here that Should Cost may be valuable as a tool in negotiating weapon system procurements in the Army.

Hypothesis 3

There is no significant difference in the percent cost reductions during negotiations between Air Force and Army acquisitions that employ the Should Cost technique.

In testing Hypothesis 3, the researchers used data on Should Cost contracts from the Air Force and the Army to try to detect any possible difference. As was the case in Part 2 above, the small sample size for the Army data was

a limiting factor. The researchers decided, however, that with six data points for the Army and 15 for the Air Force, the Mann-Whitney Test could be performed with some degree of reliability. Data for this test are drawn from Tables 3-1 and 3-5 and summarized in Table 3-6. These data are used to conduct a Mann-Whitney Test in the following manner:

Ho: Populations are identical

Ha: One population is shifted to the right or left of the other.

Reject Ho if Ua or Ub are less than or equal to 19.

The test statistic for the Air Force Should Cost contracts, Ua, and that for the Army Should Cost contracts, Ub, are then calculated as follows:

$$Ua = (15)(6) + \frac{(15)(15+1)}{2} - 130$$

$$= 80$$

$$Ub = (15)(6) + \frac{(6)(6+1)}{2} - 101$$

$$= 10$$

In this case, there exists enough evidence to reject the null hypothesis and conclude, at the 95 percent confidence level, that the population associated with Ub is shifted to the right of that associated with Ua. It can be concluded,

TABLE 3-6

AIR FORCE AND ARMY SHOULD COST DATA COMPARED

	Air Force		Army	
Contract	% Reduction	Rank	% Reduction	Rank
1	8.42	6	15.28	16
2	13.93	12	10.57	8
3	15.16	15	18.39	19
4	17.26	18	22.09	20
5	15.04	14	15.29	17
6	14.46	13	46.81	21
7	6.43	3		
8	7.16	4		
9	12.52	9		
10	13.37	10		
11	13.50	11		
12	7.73	5		
13	5.92	2		
14	9.00	7		
15	5.52	1		

based on the available data, that the application of Should Cost seems to have yielded higher percent price reductions during negotiations for the Army than for the Air Force. This may indicate that the more intensive studies conducted by the Army give government negotiators a better base from which to work than the smaller, less involved studies conducted by the Air Force. Of course, any such statement should be qualified. There are many possible factors which may have intervened because of the method in which data were obtained. These will be discussed in detail in Chapter 4. Also, one of the observations from the Army shows a percent cost reduction of 46.81 percent. There probably were some special circumstances which led to this unusually large reduction. For now, however, it probably is safe to say that there is some evidence that Should Cost analyses conducted by the Army are more effective at reducing contract costs than those conducted by the Air Force.

CHAPTER 4

SUMMATION

This chapter contains a summary of the research efforts accomplished by the authors of this thesis. Additionally, it presents conclusions based on the tests performed. Some limitations are highlighted, and recommendations are made. Finally, some areas for future research are suggested which may provide guidance to anyone interested in studying some aspect of the Should Cost method.

Summary

Should Cost is an acquisition technique first used by the Navy on an aircraft engine proposal in 1967. In short, it is:

> an approach to cost analysis which challenges a contractor's cost proposal, supporting data, and rationale by integrating into a single, fully coordinated effort the auditing, pricing, engineering, and management analysis of a contractor's manufacturing and management operations [34:1-1].

The overall purpose of Should Cost is to develop a realistic negotiation objective (31:1-1; 34:1-1).

The authors gathered a convenience sample of contract data from both DARCOM and AFSC. The data consisted of both Should Cost and non-Should Cost procurement information on individual weapons systems. Data were used to

test three hypotheses. The first two concern Should Cost and non-Should Cost contracts for Air Force and Army systems. The hypotheses assert that the percent cost reductions during negotiations are essentially the same for Should Cost contracts as those for non-Should Cost contracts. The third hypothesis involves a comparison of Should Cost contracts from the Air Force and the Army. It is hypothesized that there is no difference in percent cost reductions between the two groups.

Conclusions

Hypothesis 1

> There is no significant difference in the percent cost reductions during negotiations between Air Force contracts involving Should Cost and those where Should Cost is not used.

Based on the results of a Wilcoxon Signed Rank Test and a Mann-Whitney Test, this hypothesis cannot be rejected at the .05 significance level. Neither test indicated that the available samples provided enough evidence to conclude that the percent cost reductions for Should Cost contracts were distributed any differently than those for non-Should Cost contracts. The Air Force Should Cost efforts are apparently not achieving significant reductions in acquisition costs.

Hypothesis 2

> There is no significant difference in the percent cost reductions during negotiations between Army contracts involving Should Cost and those where Should Cost is not used.

Due to the small sample size, no quantitative statistical method was applied in this case. However, a qualitative analysis of the observations indicated that there may, in fact, be some increase in the percent cost reduction attributable to Should Cost. It appears, from the information available, that the Army's application of Should Cost is yielding positive results. Caution should be exercised, however, in accepting this conclusion. The size of the samples and the method in which they were gathered may render them less than completely representative of their respective populations.

Hypothesis 3

> There is no significant difference in the percent cost reductions during negotiations between Air Force and Army acquisitions that employ the Should Cost technique.

The researchers found that, at the 95 percent confidence level, the null hypothesis of no difference could be rejected. There is evidence that the Army application of Should Cost yields higher percent cost reductions than that of the Air Force. Ostensibly, this is due to the fact that Army Should Cost studies are more involved and, therefore, considered to be more valid by negotiators for both

the government and the contractors. However, other factors could be affecting the results. The types of weapons, different technologies, different negotiating techniques, and different contractors employed by the Army and Air Force could all have a bearing. In addition, it should be noted that the small amount of data collected on the Army was obtained from Should Cost coordinators in various organizations within DARCOM. These people probably have a vested interest in seeing that the Army continues to apply Should Cost. Of course, the same could be said of the Air Force Should Cost data; but the fact remains that the data may well be biased in favor of Should Cost. Accepting the results of the Mann-Whitney Test at face value, however, it appears that the Army is getting more out of its Should Cost studies than is the Air Force.

Limitations

The following is a list of factors which limit the degree to which the results of this study can be generalized.

1. Small convenience samples were used. Because of the general lack of available historical data, the samples used in this study are relatively small. The researchers were forced to use that information which could be obtained through inquiries to various organizations in the Air Force and Army. The result is that the samples

collected are samples of convenience. These small convenience samples may or may not be representative of the populations from which they are drawn.

2. Samples contain only Firm Fixed Price and Fixed Price Incentive Firm contracts. No data was obtained on cost reimbursement type contracts. This may not be a limiting factor since Should Cost has generally only been applied in cases where design and production specifications are well established. These same contracts usually lend themselves to Fixed Price type agreements. However, no basis was found for evaluating the effectiveness of Should Cost when cost reimbursement contracts are used.

3. Should Cost studies may have an effect on subsequent-year procurements. The possibility exists that a Should Cost study done for a particular acquisition could affect negotiations for subsequent buys of the same weapon system. In this study, however, all non-Should Cost contracts were treated the same whether or not they were preceded by a Should Cost contract. The size of the available samples did not facilitate an analysis of how important this factor is, but it should be noted that this may be a limitation to the study.

4. The use of nonparametric tests does not allow any inferences as to the magnitude of the difference between two populations. While the conclusion was drawn that there is some significant difference between percent cost reduc-

tions for Army and Air Force Should Cost contracts, the size of the difference is not known. This fact may be important. Army Should Cost studies are much more involved than those conducted by the Air Force. It follows that the Army studies are more expensive. Unless some determination can be made as to how much additional savings result from the Army's method, it is not possible to perform any cost/benefit analysis to help decide which of the two applications of Should Cost is the more effective overall. Again, however, due to the small samples, the researchers felt that parametric statistical tests could not be applied with confidence.

5. Completed contract costs are not considered. In gathering data for analysis, the researchers did not try to acquire or use information on the completed cost of the weapons systems procured. Only the contractor proposed and considered negotiated prices were considered. The reason for this is that the purpose of this study was to determine if Should Cost has a significant impact on negotiations. No attempt was made to analyze the effect of Should Cost on the accuracy of cost estimates. To the extent that inaccurate Should Cost estimates could cause contractor and government negotiators to question the validity of subsequent studies, this factor could be significant.

Recommendations

During this study, it became apparent that the Army is applying Should Cost in a very organized manner. Each of DARCOM's subcommands has assigned a Should Cost coordinator and staff. There are strict guidelines spelling out when a Should Cost study is to be done and how it is to be performed. All Should Cost activities are under the purview of a centralized Should Cost office at DARCOM Headquarters; but though the Army seems to have made positive strides toward implementing Should Cost, there does not appear to be much effort to maintain historical data on Should Cost studies. While briefing slides were obtained which cited many successful Should Cost efforts, few of DARCOM's subcommands admitted to having such information on file. If there is a centralized repository for contract cost data for the Army, it seems that the Should Cost coordinators in the various DARCOM organizations are not aware of it. If this is true, it is very possible that much valuable information is being lost. The researchers feel that a central file could be invaluable in determining the effectiveness of the Should Cost technique. If such a tool exists, certainly its true worth cannot be realized until all offices concerned with Should Cost know it is available.

Unlike the Army, the Air Force does not seem to be very enthusiastic about applying Should Cost. Fewer Should

Cost studies have been completed by the Air Force, and there have been almost none since 1977. The researchers could discern no formal structure to the Air Force's Should Cost program. The most recent Air Force publication governing Should Cost is AFP 70-7, dated 1979. The decision on when a Should Cost study is to be conducted seems to be made rather arbitrarily, with no clearly established criteria as a guide. While more information on past Should Cost studies was available, it still did not encompass all or even a majority of the studies the Air Force has completed. The researchers recommend that the Air Force, if it is serious about applying Should Cost, provide more structure and guidance to its implementation. The rather haphazard efforts to date have probably not been completely effective, and may even have been wasteful. In addition, the recommendation made earlier concerning maintenance of a central data bank for Army Should Cost information also holds for the Air Force. If Should Cost is indeed a useful tool for government negotiators to use, such a file will prove so. If it is not useful, historical data will bring that fact to light.

Suggested Areas for Future Research

The conclusions resulting from this research hardly begin to answer all the questions concerning the real usefulness of Should Cost as a procurement technique. There

are numerous areas for which a thorough investigation is warranted. These studies could be accomplished by the procuring activities or as future thesis topics.

The results of this thesis indicate that the Army may be using Should Cost more effectively than the Air Force. Further studies could analyze the approaches used by the two branches to determine what factors account for the differing results. Perhaps the Air Force could learn from the Army's greater experience in the area of Should Cost.

Another area for research concerns the effect of a Should Cost study on the contractor concerned. In view of the Army requirement to perform a Should Cost study on all sole-source procurements over $25 million, the contractor can easily anticipate such a study. It would be useful to know how this affects the contractor's proposal preparations, negotiation techniques, and production activities; or perhaps these Should Cost studies are simply accepted as part of the Defense contracting game.

In the Air Force, Should Cost studies are accomplished on a much more infrequent basis than in the Army. Because of this, it might be worth investigating how Air Force contractors react to a Should Cost study. Also, do they react any differently than do contractors when the Army conducts a Should Cost study?

One of the shortcomings of this thesis is the small samples employed. Another study similar to this one but utilizing a greater number and wider variety of weapons systems would certainly be worth the time and effort required. Certainly, if Should Cost is a waste of time and money, the DOD should be made aware of this. Just as certainly, however, if Should Cost can be of value in the acquisition process, the various branches of the service should concentrate on implementing it.

The results of this study will no doubt be received with some degree of skepticism, as they well should be. The samples used are anything but perfect. Contracts considered are for weapons systems bought in varying quantities in different years. Many of the contracts, though for the same weapons system, involved technologically different items due to design changes. Additional research is needed to determine if there is a way to normalize data from different production lots. If the changing variables could somehow be accounted for and factored out, a much clearer picture of the effectiveness of Should Cost could be obtained.

In light of the fact that cost consciousness seems to be receiving a high priority in the DOD, as evidenced by the implementation of Project Cost (1:1), the Air Force should be very concerned with whether or not Should Cost can be effective in reducing the costs of acquiring wea-

pons systems. This study, though not conclusive, casts some doubt on the ability of Should Cost to inhibit cost growth any more effectively than alternative cost analysis techniques. This is especially significant in view of the cost of performing a Should Cost analysis. It is, therefore, the opinion of the researchers that additional studies to determine the effect of Should Cost with a greater degree of certainty are warranted.

APPENDICES

APPENDIX A

CARLUCCI'S 32 ACQUISITION IMPROVEMENT ACTIONS

1. Reaffirm acquisition management principles.
2. Increase use of preplanned product improvement.
3. Implement multi-year procurement.
4. Increase program stability.
5. Encourage capital investment to enhance productivity.
6. Budget to most likely costs.
7. Use economical production rates.
8. Assure appropriate contract type.
9. Improve system support and readiness.
10. Reduce administrative costs and time.
11. Budget for technological risk.
12. Provide front-end funding for test hardware.
13. Reduce governmental legislation related to acquisition.
14. Reduce number of DOD directives.
15. Enhance funding flexibility.
16. Provide contractor incentives to improve reliability and support.
17. Decrease DSARC briefing and data requirements.
18. Budget for inflation.
19. Forecast business base conditions.
20. Improve source selection process.
21. Develop and use standard operation and support systems.
22. Provide more appropriate Design-to-Cost goals.
23. Implement acquisition process decisions.
24. Reduce DSARC milestones.
25. Submit MENs with service POM.
26. Revise DSARC membership.

27. Retain USDRE as Defense Acquisition Executive.

28. Raise dollar threshholds for DSARC review.

29. Integrate DSARC and PPBS process.

30. Increase PM visability of support resources.

31. Improve reliability and support.

32. Increase competition.

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